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ON THE RELATION OF ILLUMINATING GAS TO PUBLIC HEALTH.*

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INTRODUCTORY.

Sooner or later students of infectious diseases must give closer attention than they have yet found time to give to those environmental conditions which increase or diminish susceptibility to the various infections. When they do this, it will probably be found that obscure poisonings of various kinds play a large part in diminishing vital resistance and in increasing susceptibility. The facts presented in the present paper may be taken as a contribution to this end, for they show how in urban communities one of the commonest of public supplies—the ordinary gas supply—is today a constant menace to the public health, attended as it is not

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only by numerous fatalities but also by many non-fatal poisonings which signify widespread atmospheric impurity in urban dwellings.

The following discussion deals directly and for the most part statistically with *fatalities* from gas poisoning, but the reader must not for a moment suppose that these alone are of importance. Probably even more important are various obscure consequences of the leakage of illuminating gas in private dwellings, in public halls, and in public streets, which are as yet seldom thought of and even more seldom detected.

In 1885 an article bearing the same title as the present paper appeared in the *Annual Report of the State Board of Health, Lunacy, and Charity of Massachusetts*. It was carefully prepared by the able secretary of the Board, the late Dr. Samuel W. Abbott, and the reason for its appearance at that time was the recent perfection of a simple and convenient patented process for the manufacture of a new kind of illuminating gas, then and since known as "water-gas." This was placing upon the market an illuminating gas easier and often somewhat cheaper to make, and ranking higher in candle power, than the ordinary coal-gas derived by the distillation of bituminous coal, but a gas also much more heavily charged with the well-known poisonous substance, carbonic oxide (CO). Promoters of the new process naturally urged its adoption upon the old and established gas companies, which in some cases began to make use of it, especially for supplementary supplies, but in other cases, particularly if they were already prosperous, refused to have anything to do with it. Advantage was also taken of the water-gas process to form new and competing companies, charters being sought on the promise of lower prices and higher candle power for gas. Attempts were likewise made to buy out at low prices long-established and prosperous companies occupying inviting territory, by threats of invasion and competition through gas of lower price and higher candle power.

In Massachusetts, a comparatively thickly settled and therefore attractive territory for the manufacture and sale of gas, there were in the early 80's many and prosperous gas companies, and these for the most part, under the leadership of the largest—the Boston Gas Company—refused to adopt the new process or to be frightened

by threats of competition into selling out at low prices. Furthermore, when the water-gas interests undertook to obtain charters in Massachusetts for new and competing companies they encountered a formidable obstacle in a statute (enacted in 1880) forbidding the distribution and sale of illuminating gas containing 10 per cent or more of CO. This law it was therefore necessary to have annulled before the new process could be introduced into Massachusetts.

A battle royal for the repeal of the law now began between the older coal-gas companies on the one side, who did not care to pay for and use the new process, or did not desire to sell out to the new companies, or did not want competition, and those newer companies which for one reason or another wished to enter Massachusetts territory and sell and distribute water-gas containing more than 10 and often as much as 30 per cent of carbonic oxide. Popular attention was drawn by the old gas companies to the sanitary aspects of the question, and the battle before long raged fiercely around the question of the public health. Meantime the State Board of Health, Lunacy, and Charity referred the mooted question of the relative poisonous properties of the two gases, coal-gas and water-gas, for investigation to two professors of the Massachusetts Institute of Technology—one, the eminent sanitary chemist, the late William Ripley Nichols, and the other, a physiologist, one of the present authors (W. T. S.). These investigators soon after made a report, based upon extensive experiments upon animals, showing that, as might have been expected, much greater danger exists in water-gas than in the ordinary coal-gas (*Report of State Board of Health, Lunacy, and Charity for 1885*, p. 275). In the same report Dr. S. W. Abbott, then secretary of the Board and an excellent statistician, published the paper already referred to above in which he showed that for the preceding 20 years there had been but four deaths from gas poisoning in Massachusetts and predicted many more if the 10 per cent limit should be abandoned.

Victory in the legislature rested for a time with the older companies. But in 1888 the Gas Commissioners, who had been created in 1885, were empowered to license certain companies to make and sell water-gas for illuminating purposes, and in 1890 the 10 per cent statute was repealed, because meantime the opposition of the older

companies was for one reason or another relaxed, while the State Board of Health (as it was now and had since 1886 been called) made no effective objection. Commercial conditions had changed, and many of the coal-gas companies now wanted the privilege of making water-gas if it suited their convenience. Moreover, water-gas was being widely used in other states without public protest, and when the commissioners recommended the change it was speedily made by the legislature—with what obviously disastrous consequences to the public health we shall see in the present paper. Of the unobserved and perhaps imperceptible consequences such as diminution of vital resistance and increased susceptibility to disease, either constitutional or infectious, we have, and in the nature of the case can have, no exact knowledge. There is reason to believe, however, that here also the consequences, if less disastrous, have been no less real.

MORTALITY FROM ILLUMINATING GAS POISONING IN MASSACHUSETTS:
MORE THAN 1,200 DEATHS IN THE LAST 20 YEARS.

It was predicted by the investigators employed by the State Board in 1884 and reaffirmed by Dr. Abbott in 1885, that if water-gas should replace coal-gas in Massachusetts the consequences to the public health would probably be dangerous if not disastrous. Other experts of equal or greater eminence took precisely the opposite ground and even ridiculed the possibility of any such consequences. Among these were Professor C. F. Chandler, of Columbia University, and the distinguished English chemist, Dr. E. Frankland, who stated in a letter read during these hearings: "I have no hesitation in saying that it (water-gas) may be used with safety both in public buildings and private houses. I should be delighted to substitute this pure and powerful illuminating agent for the gas with which my house in London is at present supplied, although it is used in all the bedrooms."

More than a quarter of a century has since gone by and there are now available for study the results of a considerable, though by no means total, replacement of coal-gas by water-gas during a period of about 20 years (1890-1909). The authors of the present paper have accordingly undertaken a careful inquiry to see how

far the predictions referred to have come true. The problem is of course complicated by the fact that in spite of the legislative permission to manufacture and distribute water-gas, this has by no means wholly displaced coal-gas. The results at hand are therefore not such as we might have obtained if the replacement had been complete. Since 1890 some companies have made only water-gas; others, only coal-gas; many have made a mixture of the two, and some have made both intermittently. Still, the broad fact remains that an increasingly larger amount of the poisonous gas, CO, has been distributed since 1890 than before that date and not only absolutely but relatively to the population. The matter is further complicated by the use of illuminating gas for suicide, a subject which requires, and in the present paper will receive, special consideration and discussion.

One good result of the long and active agitation in Massachusetts was that a State Gas Commission had been provided for in 1885. Another was that in 1888 the Gas Commissioners were required to investigate, keep a record of, and report all deaths (or injuries to health) from gas poisoning within the state. From 1888 onward, therefore, we have for Massachusetts a fairly complete report of fatalities and other consequences of gas poisoning, and one probably far better than is possessed by any other state. It is perhaps the only record of this kind existing anywhere. Fortunately we have also, for the same period, the returns of the Medical Examiners concerning deaths from illuminating gas—a body of experts whose opinions possess expert value.

We have taken for study the *fatalities*, only, from gas poisoning. Of the numerous injuries which do not result fatally we have, and can have, no complete record. Some are reported by the Gas Commissioners, but many are never reported at all and many less striking and seemingly transient effects, such as headache or malaise, are neither heard nor even thought of as due to gas poisoning.

As stated above, we have obtained the records of death from gas poisoning in Massachusetts from two sources, namely, the reports of the Gas Commissioners, and the returns of the Medical Examiners. The former are published in the Commissioners'

Annual Reports, the latter in the *State Registration Reports*. The Gas Commissioners' records we owe to a provision of law already referred to, permitting the use of water-gas, but at the same time requiring all gas companies to return to the Commissioners a written report of any death or injury due to gas distributed by the company in question. On the whole this arrangement has worked out fairly well, although in the early years the Commissioners complained with reason that some deaths were not reported. The Commissioners' records begin with the year 1886 and it is interesting to note that poisoning by illuminating gas did not earn itself a separate place in the classification of deaths reported by the Medical Examiners until that same year. The figures of the latter are also available, therefore, since 1886. For data previous to 1886 we have only Dr. Abbott's valuable paper of 1885.

The table now given (Table A) shows side by side the figures derived from the two independent sources mentioned. These data are for the *calendar* year indicated, and include only deaths from poisoning by illuminating coal-gas and water-gas. Deaths from oil gas or acetylene gas and deaths caused by gas explosions, or from burning by gas, have been excluded.

TABLE A.
DEATHS FROM ILLUMINATING GAS POISONING IN MASSACHUSETTS.
(1886-1909.)

Year Ending Dec. 31	Medical Examiners' Returns	Gas Commissioners' Returns
1886	5	0
1887	6	0
1888	6	0
1889	5	2
1890	12	10
1891	16	14
1892	28	18
1893	27	25
1894	43	33
1895	31	26
1896	52	51
1897	63	58
1898	78	77
1899	65	65
1900	45	46
1901	37	37
1902	63	62
1903	71	72
1904	61	59
1905	77	72
1906	68	71
1907	147	145
1908	123	115
1909	102	99
Totals	1,231	1,157

The table shows substantial agreement in the two sets of data, especially in the later years. The Medical Examiners' figures are probably the more accurate.

Some of the salient features of this table are the sharp rise beginning in 1890 from a very low previous level and continuing

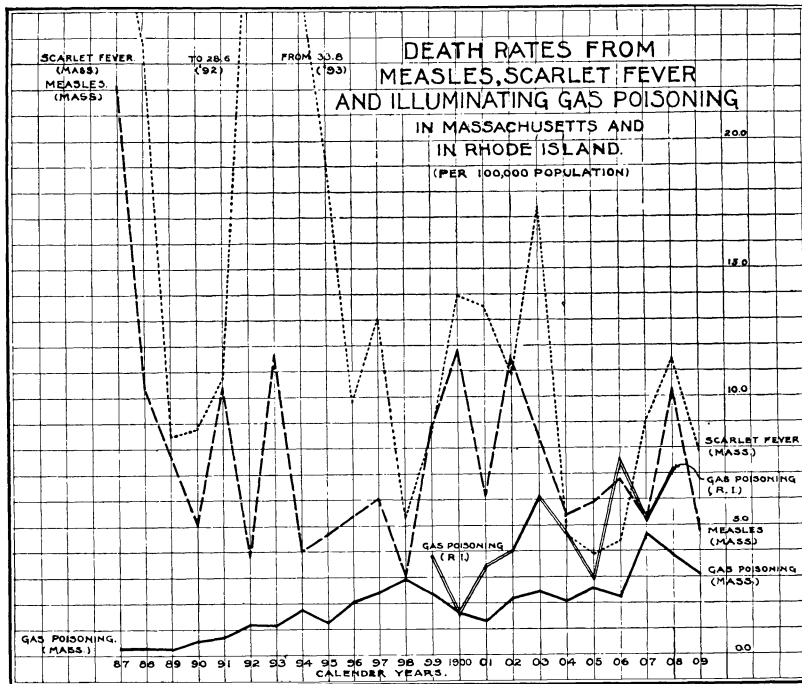


CHART I.

to a high maximum in 1898, with a fall to a lower level in 1901, followed by a rebound which in 1907 reached the highest point in the entire table. From five or six deaths each year before 1890, the number rose to 147 deaths from poisoning by illuminating gas in 1907. Previous to 1885, according to Dr. Abbott, there had been only four deaths during 20 years.

The same fluctuations which appear in this table may be seen in more graphic form, but as death *rates*, in the lowest curve—the heavy black line marked “Gas Poisoning, Mass.”—on Chart I.

Variations corresponding more closely to those in Table A may

also be seen upon Chart 2 in the heavy black line marked "Deaths by Gas Poisoning." It should be noted, however, that the correspondence of these data is not exact in all cases, since the figures in the table above and the curve on Chart 1 represent *calendar* years and rates, while the heavy black line on Chart 2 represents actual deaths and years ending *June 30*. The highest point of the line on Chart 2 thus falls in 1908 and not as on Table A and Chart 1, in 1907.

SOME DEATH RATES FROM SCARLET FEVER, FROM MEASLES, AND
FROM ILLUMINATING GAS IN MASSACHUSETTS
AND IN RHODE ISLAND.

We can best realize the growing importance of illuminating gas as a cause of death by comparing its mortality rate for a period of years with the death rates from such familiar diseases as scarlet fever and measles in States having trustworthy vital statistics. For this purpose we have computed the following statistics for two such States; namely, Massachusetts and Rhode Island:

TABLE 1.
DEATH RATES FROM SCARLET FEVER, FROM MEASLES, AND FROM ILLUMINATING GAS IN MASSACHUSETTS
AND IN RHODE ISLAND.
(Per 100,000.)

Calendar Years	Scarlet Fever (Mass.)	Measles (Mass.)	Illuminating Gas (Mass.)	Illuminating Gas (R.I.)
1887.....	28.80	22.08	0.29	
1888.....	23.78	10.33	0.29	
1889.....	8.49	7.85	0.23	
1890.....	8.76	5.09	0.54	
1891.....	10.74	10.31	0.70	
1892.....	28.56	3.76	1.19	
1893.....	33.80	11.52	1.13	
1894.....	26.51	4.00	1.76	
1895.....	19.31	4.63	1.24	
1896.....	9.73	5.35	2.03	
1897.....	13.05	6.03	2.40	
1898.....	5.25	2.05	2.91	
1899.....	8.56	8.78	2.37	
1900.....	13.94	11.77	1.60	1.63
1901.....	13.52	6.03	1.30	3.42
1902.....	10.84	11.53	2.18	4.01
1903.....	17.42	8.44	2.43	6.10
1904.....	4.65	5.39	2.06	4.60
1905.....	3.90	5.89	2.56	1.92
1906.....	4.39	6.76	2.21	7.50
1907.....	9.04	5.18	4.67	5.15
1908.....	11.46	10.27	3.82	7.15
1909.....	7.86	4.77	3.10	

Table 1 shows strikingly how important poisoning by illuminating gas has recently become as a cause of death in Massachusetts and in Rhode Island; and the same facts are displayed graphically by the diagrams on Chart 1 (p. 386). The death rate from the two contagious diseases (scarlet fever and measles) has evidently greatly

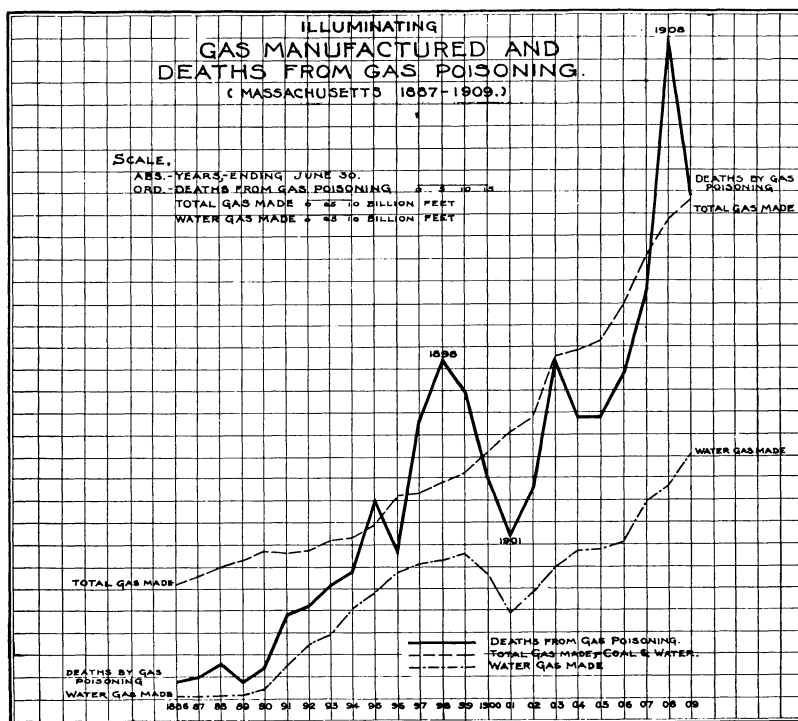


CHART 2.

declined, while that from illuminating gas poisoning has greatly increased, so much so that the latter bids fair soon to exceed the former.

The death rate from poisoning by illuminating gas was higher in Massachusetts in 1907 than from scarlet fever in 1905 and 1906, while in Rhode Island the death rate from illuminating gas from 1903 to 1907 was at times higher than that in Massachusetts from either scarlet fever or measles. Poisoning by illuminating gas has

evidently become in Massachusetts and in Rhode Island a cause of death nearly as effective as are scarlet fever or measles. It has of late years claimed as many victims as has typhoid fever in some American and many German cities.

AMOUNTS AND KINDS OF ILLUMINATING GAS MANUFACTURED IN
MASSACHUSETTS (1886-1909).

The following table (Table 2), the main features of which appear also on Chart 2, p. 388, shows the amounts of total illuminating gas (coal-gas and water-gas) and of water-gas, manufactured in each year in Massachusetts. The data are derived from the *Annual Reports* of the Gas Commissioners.

TABLE 2.

AMOUNTS OF ILLUMINATING GAS MADE AND OF WATER-GAS, AND DEATHS FROM ILLUMINATING GAS IN
MASSACHUSETTS.
(1886-1909.)

Years Ending June 30	Total Coal- and Water-Gas Made (Million Cu. Ft.)	Water-Gas Made (Million Cu. Ft.)	Deaths from Illuminating Gas
1886.....	2,625	12	...
1887.....	2,765	28	5
1888.....	3,010	47	8
1889.....	3,156	78	4
1890.....	3,346	212	7
1891.....	3,300	777	19
1892.....	3,370	1,231	21
1893.....	3,594	1,467	26
1894.....	3,671	2,022	29
1895.....	3,955	2,413	45
1896.....	4,639	2,876	33
1897.....	4,731	3,090	63
1898.....	4,901	3,167	77
1899.....	5,120	3,265	70
1900.....	5,608	2,881	50
1901.....	6,059	1,961	37
1902.....	6,372	2,400	48
1903.....	7,776	2,989	78
1904.....	7,882	3,335	64
1905.....	8,126	3,373	64
1906.....	8,902	3,536	74
1907.....	9,998	4,471	92
1908.....	10,902	4,862	148
1909.....	11,360	5,518	114

The same facts are depicted graphically upon Chart 2, which deserves and will repay careful study. The apparent discrepancy between these data of deaths and those given on other tables is due to the fact that the "years" end here on June 30, and not as in the other cases on December 31.

A COMPARISON OF MORTALITY FROM ILLUMINATING GAS IN MASSACHUSETTS WITH AMOUNTS AND KINDS OF GAS MANUFACTURED.

From Table 2 and Chart 2 it appears that the total quantity of illuminating gas made in Massachusetts has, on the whole, increased rather steadily, year by year, since 1886. Once only has there been a slight decrease (in 1891) and at times (as in 1896, 1903, 1906, 1907, and 1908) the increase has been very rapid. The curve on Chart 2 shows also on the whole a much more rapid annual increase of output in the later than in the earlier years.

The total quantity of water-gas made shows likewise, on the whole, a great increase since its distribution for illuminating purposes became legally possible in 1890. But the water-gas curve, though approximately parallel to the total gas curve for the years since 1901, was not so before that time. On the contrary, from 1890 to 1896 it was rising much more rapidly; from 1899 it was nearly parallel; and from 1899 to 1901 it declined sharply, whereas the total gas production increased more rapidly than before.

The third line on Chart 2, the heavy black line, shows the deaths, year by year, from illuminating gas in Massachusetts, and, like the other two lines, it shows on the whole a great increase since 1890. It is, however, much less regular in form, and the increase which it shows is much greater than that shown by the other two lines. To the line of total gas production it shows only the most general relation of rapid increase, and that only with numerous and striking exceptions of departure, as in 1896, 1899, 1900, 1901, 1904, 1905, and 1909. If the number of deaths had merely increased *pari passu* with the total amount of gas manufactured, we must have supposed that the poisonous quality of the gas had remained constant and the habits of the consumers unchanged. But this is clearly not the case. The deaths increased very much more rapidly from 1890 to 1898 and from 1901 to 1908 than did the total amount of gas made, while from 1898 to 1901 and from 1903 to 1906 deaths actually decreased while total gas production increased. We are therefore driven to seek some other explanation for the great increase of deaths from illuminating gas than the mere expansion of the industry and the increasing use of gas.

For an explanation we need not look far. If, instead of com-

paring the death curve with the curve of total illuminating gas, we compare it with that of water-gas made, we find a remarkable, though not a perfect, general correspondence. Except in 1896, 1899, 1904, and 1909, this general correspondence is close and striking, both curves rising and falling together, though often at different rates. The general increase in deaths, barring the exceptional years noted, may therefore be readily explained by the general increase in the amount of water-gas made.

From 1898 to 1908 the amount of total gas made had doubled, while the fatalities had not quite done likewise. But while the quantity of total gas made increased about fivefold from 1886 to 1908, the fatalities increased nearly thirty fold. At the same time we find the variations in the amount of water-gas manufactured coinciding much more nearly with the fluctuations in the number of deaths. The remarkable increase of such deaths in 1891 corresponds with the first appearance of any large amount of water-gas. And when the deaths reached a maximum in 1897-99 water-gas had reached a percentage proportion of the total output which it has never equaled either before or since.

In 1900 the New England Gas and Coke Company installed a large coal-gas plant in Everett, and the effect of the introduction of their product into the illuminating gas of the Metropolitan District was to produce an actual decrease for three or four years in the total amount of water-gas manufactured in the state. It is noteworthy and significant that this decrease corresponds closely with the low phase of 1901 in the curve of deaths by gas poisoning. But, as indicated by the diagram, the natural growth of the gas industry soon called for more gas. The check to the production of water-gas in 1901 was only temporary and the increased output since 1901 has been attended by a corresponding increase in deaths from gas poisoning.

In consideration of all these facts we are warranted in concluding that the amount of water-gas produced stands in some close relation to the number of deaths by illuminating gas. This conclusion is justified and confirmed by a comparison of the percentage which water-gas formed of the total gas manufactured, with the deaths per billion feet of total gas produced. If the water-gas is really to

blame, the larger the percentage of water-gas the more dangerous should be each unit of the resultant product. On the other hand, by dividing the deaths from gas poisoning by the total amount of gas made, we should obtain a measure of the poisonous effect of a unit of the total gas. In other words, if the theory that water-gas has been the primary cause of the deaths by gas poisoning is true, we should expect to find some general agreement between the percentage of water-gas to total gas made, and deaths by gas poisoning for each unit, such as a billion feet, of total gas made. That such agreement actually exists appears from Table 3 and its corresponding chart (Chart 3).

TABLE 3.
PERCENTAGE WHICH WATER-GAS MADE WAS OF TOTAL ILLUMINATING GAS
MADE, AND DEATHS PER BILLION CUBIC FEET OF TOTAL
ILLUMINATING GAS MADE (MASSACHUSETTS, 1887-1909).

Year Ending June 30	Percentage of Water-Gas Made to Total Gas Made	Deaths per Billion Cubic Feet of Total Gas Made
1887.....	1.01	1.09
1888.....	1.56	1.17
1889.....	2.43	0.64
1890.....	6.34	2.10
1891.....	22.20	5.76
1892.....	36.60	6.24
1893.....	40.80	7.24
1894.....	55.00	7.90
1895.....	61.00	11.39
1896.....	62.00	7.12
1897.....	65.40	13.31
1898.....	64.60	15.70
1899.....	63.80	13.67
1900.....	51.40	8.92
1901.....	32.30	6.11
1902.....	37.70	7.54
1903.....	38.40	9.78
1904.....	42.30	8.12
1905.....	41.30	7.88
1906.....	39.70	8.31
1907.....	44.70	9.20
1908.....	44.50	13.57
1909.....	48.60	10.05

Table 3, and especially Chart 3, shows a remarkable concordance between the percentage of water-gas manufactured year by year and the corresponding death rate (ratio) from illuminating gas per billion feet of total gas made. In spite of some differences (as, for example, 1896, 1904, 1906, 1908, 1909), it is difficult to avoid the conclusion that the water-gas curve and the death curve stand in the relation of cause and effect.

The agreement between the variations in the percentage of water-gas made and the number of deaths year by year is obviously not absolute, but when we reflect upon the actual conditions under which water-gas is made and distributed, we may well be surprised that the agreement is as close as it is. For illuminating gas is sold in Massachusetts by many companies and under a great

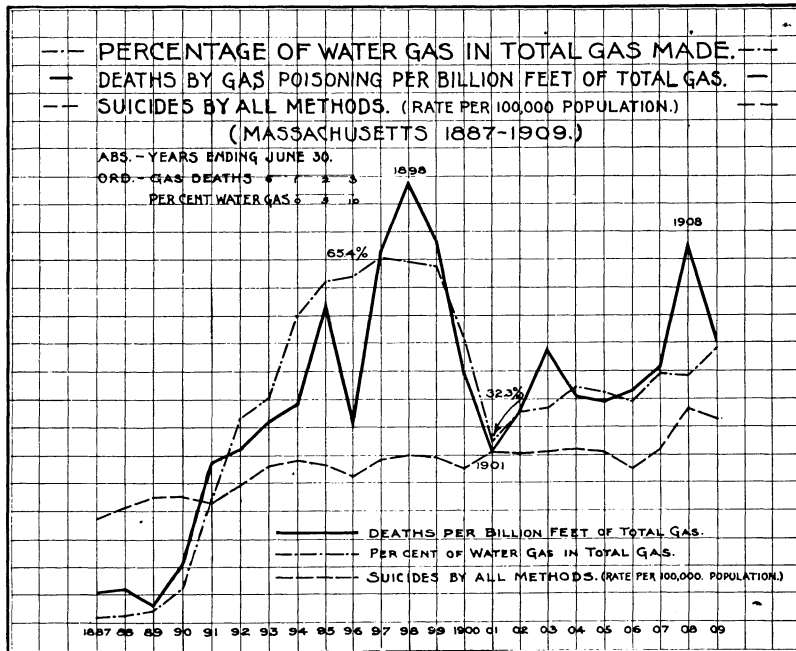


CHART 3.

variety of conditions. Some companies distribute only coal-gas and some only water-gas, but most distribute a mixture of the two. And this mixture may vary widely from time to time in the percentage of the two gases. Again, there is, as we shall learn beyond, a marked seasonal variation in the deaths from illuminating gas, and there is good reason to believe that the mildness or severity of Massachusetts winters may cause annual as well as seasonal variations in the mortality from gas poisoning. These various factors naturally forbid any absolute correspondence between the amount

of water-gas made and the deaths from gas poisoning. When we consider this great variety of circumstances, the wonder is, not that the two curves occasionally differ, but that they run so nearly parallel.

THE USE OF ILLUMINATING GAS IN MASSACHUSETTS FOR PURPOSES OF SUICIDE.

Since 1890 illuminating gas has been gradually discovered by the public to be a convenient and effective means of suicide. Whereas before that time it was very difficult to commit suicide

TABLE B.
DEATHS FROM ILLUMINATING GAS POISONING (MASSACHUSETTS, 1886-1909).
(Medical Examiners' Returns.)

Years Ending June 30	Accidental Deaths	Suicidal Deaths	Total Deaths
1886*	1	1	2
1887	4	1	5
1888	7	1	8
1889	2	2	4
1890	5	2	7
1891	18	1	19
1892	9	12	21
1893	7	9	26
1894	14	15	29
1895	28	17	45
1896	20	13	33
1897	47	16	63
1898	48	29	77
1899	35	35	70
1900	35	15	50
1901	11	26	37
1902	9	39	48
1903	47	30	77
1904	29	35	64
1905	41	23	64
1906	35	39	74
1907	41	51	92
1908	55	93	148
1909	43	71	114
1909†	23	31	54
Totals	624	607	1,231

* First six months.

† Second six months.

by the use of illuminating gas, and probably very few would-be suicides resorted to its use, it has come of late years to be one of the easiest and surest agents of self-destruction. The reports of the Medical Examiners contain ample evidence of this fact.

Table B, prepared by us from the returns of the Medical

Examiners, shows not only the use, but the increasing use, of illuminating gas for purposes of suicide. At the same time this table is a sufficient answer to those who have the assurance to proclaim that, excepting as it is used by suicides, water-gas is no more dangerous to life than is coal-gas.

Of the 1,231 deaths by gas poisoning reported by the Medical Examiners in the years 1886-1909, 607, or 49.4 per cent, were

TABLE 4.
DEATH RATES FROM POISONING BY ILLUMINATING GAS AND FROM ACCIDENTAL AND FROM SUICIDAL
POISONING BY ILLUMINATING GAS, (MASSACHUSETTS, 1887-1909).
(Medical Examiners' Returns.)

Year Ending June 30	Gas Deaths (Totals)	Gas Accidents	Gas Suicides
1887.....	0.251	0.19	0.5
1888.....	0.381	0.33	0.05
1889.....	0.180	0.09	0.09
1890.....	0.31	0.22	0.09
1891.....	0.831	0.79	0.04
1892.....	0.600	0.33	0.51
1893.....	1.034	0.71	0.38
1894.....	1.184	0.57	0.61
1895.....	1.804	1.12	0.68
1896.....	1.129	0.78	0.51
1897.....	2.40	1.79	1.61
1898.....	2.87	1.79	1.08
1899.....	2.55	1.28	1.27
1900.....	1.78	1.25	0.54
1901.....	1.30	0.39	0.91
1902.....	1.66	0.31	1.35
1903.....	2.63	1.61	1.03
1904.....	2.16	0.98	1.18
1905.....	2.13	1.36	0.77
1906.....	2.41	1.14	1.27
1907.....	2.92	1.30	1.62
1908.....	4.60	1.71	2.89
1909.....	3.46	1.31	2.16

reported by them to be suicides and the remainder accidental deaths. Table B gives these data in detail for the separate years.

We have also computed, for the same period, the death *rates* from illuminating gas and those by illuminating gas from accidental sources and from suicidal sources, as reported by the Medical Examiners (Table 4 and Chart 4). It is hardly necessary to repeat that these, while obviously open to the objection that they represent merely the opinion of the Medical Examiners, are the best data we have and are probably on the whole not far wrong.

It may, of course, be urged that it is often difficult even for expert medical examiners to discover whether or not a particular

death was suicidal or accidental. But even if this be granted and if some deaths reported as accidents were really suicides, the reverse may likewise be true, and there is no good reason to doubt that in a large percentage of cases the Medical Examiners' returns are correct. If any reasonable doubt could exist as to the fact that many accidental deaths do occur from poisoning by illuminating

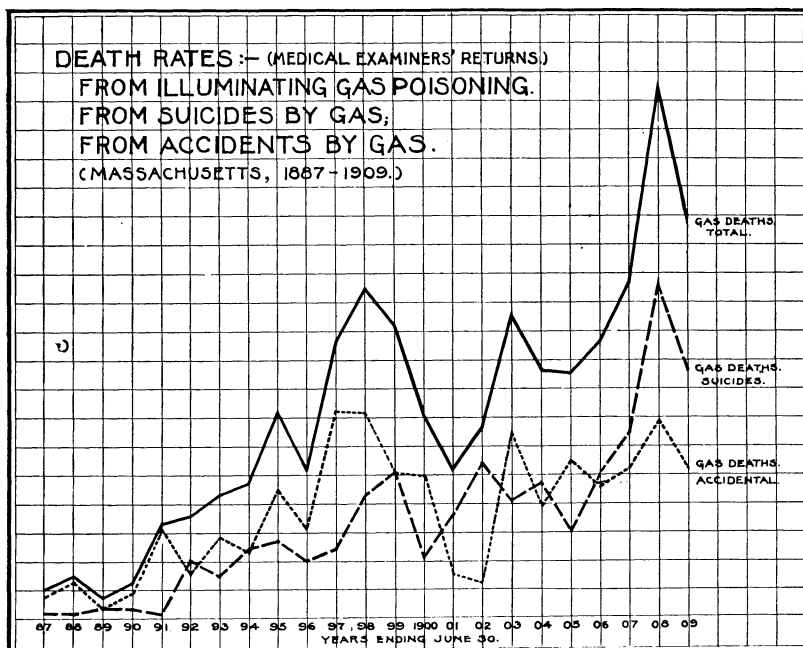


CHART 4.

gas it would be dissipated by an examination of the data shown on the following table (Table 5) and its corresponding chart (Chart 5).

This table and its corresponding plate shows how sudden was the increase in 1891 of deaths from illuminating gas, an increase much more reasonably explained by increase in accidents than by increase in suicidal use of the new and as yet generally unknown poison, especially when we observe that this increase was accompanied by a decrease in the whole number of suicides for the year. Again, in 1895, with no increase in the whole number of suicides, there was a very large increase in the number of deaths from poison-

ing by illuminating gas; in 1904, while the whole number of suicides was increasing, deaths from illuminating gas decreased; while in 1906 the reverse was the case. Undoubtedly, there is on the whole

TABLE 5.
DEATHS FROM SUICIDE BY ALL METHODS, DEATHS FROM ILLUMINATING GAS, AND POPULATION
(MASSACHUSETTS, 1887-1909).
(Medical Examiners' Returns.)

Year Ending June 30	Suicides by All Methods	Deaths from Illuminating Gas	Population of the State
1887.....	152	5	
1888.....	175	8	
1889.....	196	4	
1890.....	202	7	2,238,943
1891.....	194	19	
1892.....	231	21	
1893.....	270	26	
1894.....	284	29	
1895.....	282	45	2,500,183
1896.....	269	33	
1897.....	304	63	
1898.....	321	77	
1899.....	323	70	
1900.....	312	50	2,805,343
1901.....	347	37	
1902.....	350	48	
1903.....	358	77	
1904.....	369	64	
1905.....	366	64	3,003,680
1906.....	338	74	
1907.....	390	92	
1908.....	494	148	
1909.....	476	114	

a striking correspondence in the forms of the two curves, such as ought to exist when we remember that (as shown in Table B) about one-half of all the deaths in the lower line are an important factor in the upper.

A STUDY OF THE SEASONAL DISTRIBUTION OF DEATHS FROM ILLUMINATING GAS IN MASSACHUSETTS.

We had not been studying the general subject of illuminating gas poisoning very long before it became plain that such poisoning bears a close relation to the seasons. And this relation proved to be almost precisely what might have been anticipated. Deaths from illuminating gas are comparatively few in summer and comparatively many in winter, as is shown by the first column in the following table, and by the heavy black line on the corresponding chart

(Chart 6) based upon it. The reason is, of course, because in summer, with open windows, short nights, and outdoor life, people in Massachusetts are much less exposed to gas poisoning than in winter, when they are housed most of the time, often in apartments

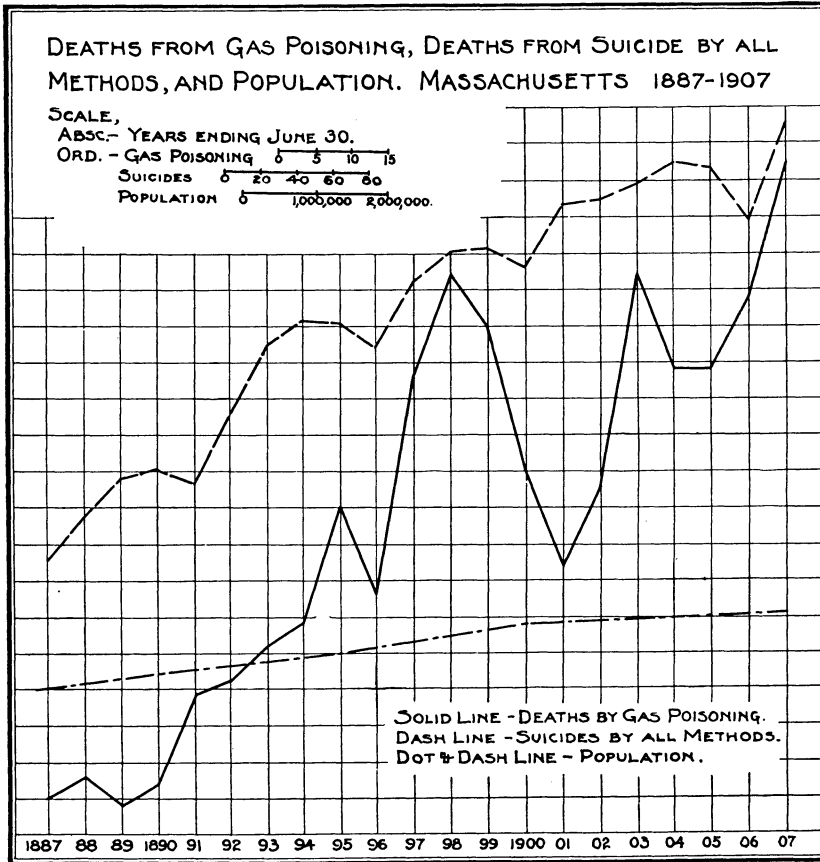


CHART 5.

pipied for gas and having little or no ventilation. Similar considerations probably make gas poisoning also largely a matter of latitude—northern cities suffering more from gas poisoning than southern cities—and likewise produce annual variations according as the winters are mild or severe.

This table and the corresponding chart (Chart 6) disclose many interesting and important details. December stands out as the month of most deaths, and December is one of the months of shortest days and longest nights as well as of lowest average temperature. It is therefore one of the times of greatest use of gas, of most indoor life, and of least ventilation by open doors and

TABLE 6.
SEASONAL DISTRIBUTION OF DEATHS FROM ILLUMINATING GAS, OF DEATHS BY ACCIDENT FROM
ILLUMINATING GAS, OF DEATHS BY SUICIDE FROM ILLUMINATING GAS, AND OF SUICIDES
BY ALL METHODS (MASSACHUSETTS, 1886-1909).
(Medical Examiners' Returns.)

Month	Total Deaths from Illuminating Gas	Accidental Deaths from Illuminating Gas	Suicidal Deaths from Illuminating Gas	Suicides by All Methods
January	106	73	33	568
February	97	49	48	462
March	106	59	47	597
April	116	51	65	749
May	90	36	54	686
June	67	30	37	647
July	57	20	37	634
August	64	23	41	603
September	92	34	58	611
October	144	77	67	655
November	143	80	63	594
December	149	92	57	541

windows. It is not surprising that these conditions are correlated with the highest mortality from poisoning by illuminating gas. What is remarkable is that the deaths from this source were almost equally numerous in October and November, although the days are then longer, the average temperature considerably higher, and the possibility of comfortable sleeping with more open windows is much greater; while January, which in length of day and temperature closely resembles December, shows fewer deaths than does December from illuminating gas.

July, as might be expected, shows the smallest number of deaths (57), June (67) and August (64) more, and each about the same number, while September yields an increase of more than 40 per cent over June and over August. These facts are not surprising when we reflect upon the cooler and longer nights of June and August over those of July, and the much cooler nights—often with frosts—of September over those of June and of August. But beginning with October there is no great difference in the deaths

by months until we come to January, when in spite of very cold weather and very short days we find a marked decrease of deaths from poisoning by illuminating gas, the deaths for January, February, March, April, and May differing astonishingly little.

We are aided in explaining these various figures by the fact that April and October are the months of most numerous suicides, not

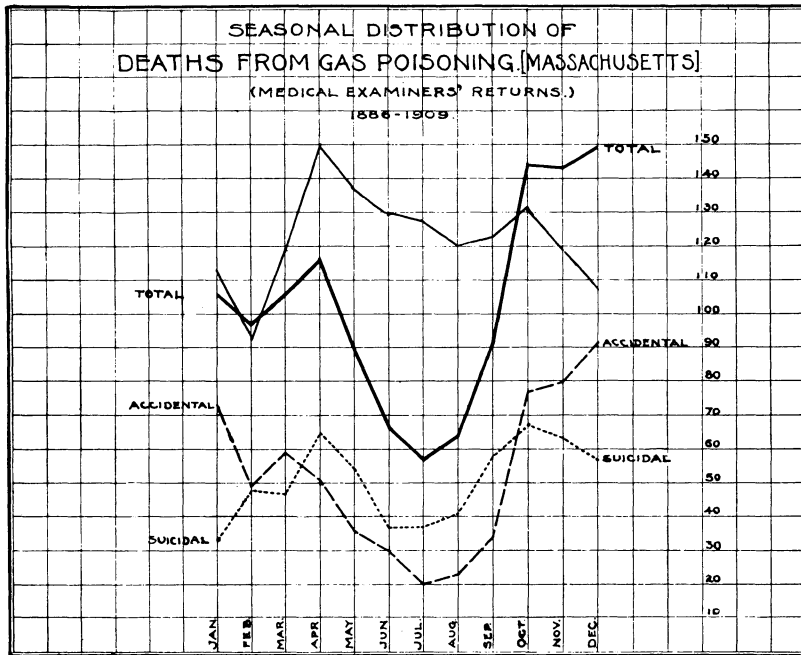


CHART 6.

only by all methods (as shown by the last column in Table 6 and by the corresponding, thin, solid line, without legend, on Chart 6), but also by illuminating gas; so that the curve of total deaths by illuminating gas is necessarily quite different from what it would be if it represented only those deaths due to accident, and if accidents were solely due to considerations correlated with the movement of the seasons—such as temperature and length of days—and effective ventilation. We find here, readily enough, a satisfactory explanation of the large number of total deaths in October (144) and November

(143) as compared with December (149) when the deaths from suicide (both by all methods and by gas) were passing during these months from a maximum to a much lower level. The fact appears to be that while the accidental gas deaths were increasing during this quarter (as appears in Table 6 and Chart 6 and as would be required by theory) the suicidal gas deaths were declining almost *pari passu*; so that a remarkably even and high total of deaths from illuminating gas was maintained during this last quarter of the year.

In the next quarter (January–March) the gas suicides were considerably fewer, as were also the deaths from accidental gas poisoning, and very likely the same explanation holds good of both these causes of death; namely, that conditions had now become comparatively endurable, those that were absolutely intolerable having already destroyed their victims or having been changed for the better. The high number of total deaths in April appears to be chiefly due to the excess of suicides in general characteristic of that month, as does also the lower but still large number in May, when, as required by theory, the seasonal conditions do not greatly favor accidental gas poisonings and when, in fact—as shown by our figures—such poisonings are comparatively few.

It is also interesting to note, in passing, that upon Table 6, and excepting in the first quarter, a close correspondence is shown between the frequency of suicides by all methods and those by illuminating gas.

THE RELATION OF CERTAIN COMBUSTION PRODUCTS OF ILLUMINATING GAS TO THE PUBLIC HEALTH.

The principal combustion products of illuminating gas are carbonic acid (CO_2), water (H_2O), light, and heat. Small, but not insignificant amounts of ammonia, sulfurous acid, soot, and other substances are also produced.

Carbonic acid, an inevitable product of all complete combustion of carbon compounds, while not a desirable addition to the atmosphere of a dwelling, a store, or a workshop, is probably, unless present in very large quantities, of but little consequence from the standpoint of health or comfort.

Water vapor, which is also copiously and inevitably produced in the ordinary combustion of illuminating gas, is probably of more importance than is carbonic acid to health and comfort. Evidence of its abundant presence may often be seen in the water upon the windows of shops, of stores, or of living rooms, upon which it condenses freely and runs down, sometimes almost in streams. The high humidity to which this testifies is often prejudicial to the comfort, and probably also to the health or working capacity, of the inmates.

The light produced by illuminating gas varies widely in amount and composition. The old-fashioned coal-gas gave an agreeable and apparently powerful yellowish light, and when those who were accustomed to it began to be served with water-gas, many found the latter bluish and less efficiently luminous. Much here depends, no doubt, upon the special form of burner, or "tip" employed, but after all is said and done there are many—of whom the senior author is one—who, having lived with both kinds of gas (and with many kinds of mixtures of the two) would gladly go back to the old-fashioned coal-gas at double the present cost of gas, not only because of its greater safety, but also because of its greater and more agreeable illuminating effects.

As to the question of heat produced by combustion—a question of great economic importance for those using gas as a source of power, or for cooking or heating purposes, and of much hygienic significance for persons occupying rooms lighted by gas, it should be said that water-gas is not greatly superior to coal-gas, while, since much heat is produced by the combustion of either gas, their hygienic effects in this particular are probably not very different. Electric lighting (although open to other objections) is vastly preferable to gas lighting on the score of heat production and that of objectionable chemical products.

Among the less abundant products of the combustion of illuminating gas is sulfurous acid. Most coals used in the manufacture of gas—and hence known as "gas coals"—contain a small percentage of sulfur, some of which appears in illuminating gas as hydrogen sulfide and some as bisulfide of carbon, or other sulfur compounds. These, when burned, form sulfurous acid, an irritating and poison-

ous gas. Most of the sulfur compounds in illuminating gas are, however, removed by processes of purification during manufacture, but owing to the difficulty of complete removal, 20 grains of sulfur in every hundred cubic feet have generally been allowed by law to remain in the gas distributed to the public. The 20-grain limit has prevailed in Great Britain for about half a century, and was apparently copied into American statutes when legal regulation of the quality of illuminating gas was first undertaken—in Massachusetts, for example, in 1861. And until quite recently no objection to this legal limit has been raised by the gas manufacturers or by anyone else. A few years ago, however, the London gas companies sought to have this sulfur regulation removed, claiming that because the best gas coals are now scarce, it is much more difficult than formerly to procure coals low in sulfur, so that processes for the removal of sulfur have become more costly and really burdensome to the industry of gas manufacture. And after protracted hearings with the taking of much testimony the sulfur restrictions were, in fact, removed in England. A little later gas manufacturers in the United States and in Canada came forward with a similar demand, and in Massachusetts the legal limit for sulfur has now been raised from 20 grains to 30 grains per 100 cubic feet of gas. A complete discussion of the whole subject of the relation of the combustion products of sulfur compounds in illuminating gas to the public health would require a monograph. Suffice it to say that the testimony taken by the British Commission having the matter in charge, and by the Gas Commissioners of Massachusetts (not to mention other authorities) was voluminous, instructive, and important, and deserving of careful attention. It is the opinion of the authors of the present paper that the British authorities were not sufficiently considerate of the public health aspects of the subject when they allowed all restrictions upon the sulfur content of illuminating gas to be removed, and that the Massachusetts Gas and Electric Light Commissioners acted more wisely when they declined to follow the British example and merely relaxed somewhat the severity of the legal requirements regarding sulfur.

Illuminating gas is required by law in Massachusetts (and in many other places) to be free from ammonia as well as from

sulfuretted hydrogen, but this is more because of injury to fixtures than because of danger to health.

THE PREVENTION OF POISONING BY ILLUMINATING GAS.

The question naturally arises, What can be done for the protection of the public health against poisoning by illuminating gas, which as a cause of sickness and death now almost equals in Massachusetts and Rhode Island some of the dreaded infectious and contagious diseases? We must admit at the outset that about one-half of the recorded deaths from this source are voluntary or suicidal, but while recognizing this fact we have no right to dismiss it as irrelevant to the present discussion. The State seeks, as far as possible, to prevent suicide, by laws, for example, regulating the sale of other poisons and of firearms, and may well regard with concern the general distribution to the public of a dangerous gas readily available for self-destruction.

Even more serious are the public consequences of the widespread distribution to sick and well for industrial and domestic purposes of a dangerous and highly poisonous substance, insidious in its mode of operation, quickly harmful in its effects, and delivered under such pressure that leaks are frequent. Those who have read and reflected upon the facts given in the preceding sections will hardly need to be told how prejudicial to the public health even small leaks of illuminating gas must be, especially if long continued, while the leakage or escape of larger amounts is well known to be often fatal to those exposed. The simplest and most natural remedy for these evils would be, of course, to return to the former practice of making and distributing only coal-gas instead of water-gas or a mixture of the two. But here, as so often in public health problems, a balance must be struck between industrial advantages accruing to the public in less cost, and some saving of life and health. If the industrial, economic, or efficiency gain is very great, it may justify some increase of danger to life and health. But if it is not very great, then life and health have the prior claim. In the present case it is not claimed that water-gas in Massachusetts or Rhode Island is, as a rule, much if any cheaper to manufacture than is coal-gas, but that it is very convenient to produce because

more quickly made when needed. The claims of the advocates of water-gas in 1884 that this gas would furnish 24 candles of light against the 16 candles of the old-fashioned coal-gas do not appear to have been substantiated, since most of the gas now distributed in Massachusetts equals—according to the State Inspector—only about 18 candles. The price of gas to the consumer has, however, fallen greatly since 1884, and this decrease in cost, as far as it is due to the use of water-gas, must be balanced against the damage done to the public health by the loss of more than 1,200 lives and an unknown amount of less obvious injury to life and health.

Undoubtedly a mixture of coal-gas and water-gas, such as is often distributed today, is less dangerous than is water-gas alone, but this appears to be merely because the dangerous constituent, carbonic oxide, so abundant in water-gas, is diluted by the process of mixture; and up to a certain point, the greater the dilution, the less the danger. We know from experience that when carbonic oxide forms only about 6 per cent of illuminating gas very little danger exists. We also know from experience that 20–30 per cent of carbonic oxide means danger. But whether 10 per cent or perhaps 12 per cent might be allowed without much danger, we do not yet know. It should, however, be possible to determine by experiment the minimum amount safely allowable.

Meantime, in view of the appalling loss of more than 1,200 lives which has occurred in Massachusetts since the 10 per cent restriction was removed, it seems not unfair or unreasonable to demand a return to the 10 per cent limit until such time as evidence shall be forthcoming that a higher percentage will properly safeguard the public health.

APPENDIX.

A DIGEST OF LEGISLATION IN MASSACHUSETTS BEARING UPON THE RELATION OF ILLUMINATING GAS TO PUBLIC HEALTH.

FRANZ SCHNEIDER, JR.

Acts of 1861, chap. 168. *An Act for the Inspection of Gas Meters, the Protection of Gas Consumers, and the Protection and Regulation of Gas Light Companies.*

SECTION 1. Appointment of inspector. His duties. SEC. 2. His tenure of office; compensation; oath of office; bonds; etc. SEC. 3. List of gas companies. Inspector's salary, how paid. Delinquent companies, proceedings against. SEC. 4.

Appointment of deputies. Qualifications, disabilities, fees, etc. SEC. 5. Standard of measure. SEC. 6. Sealing of meters. SEC. 7. Apparatus. SEC. 8. Test gas-holders. Test meters. Examination, proving and stamping. Record of meters. SEC. 9. Expense of testing meters. SEC. 10. Standard of gas. Twelve candle-power minimum. "Whenever requested by the Mayor and Aldermen of any city or the Selectmen of any town, the inspector shall report to them whether the gas supplied is of the legal standard, and also whether it is sufficiently well purified from sulphuretted hydrogen, ammonia and carbonic acid." SEC. 11. Right of companies to enter premises, etc. SEC. 12. Right to stop gas, etc. SEC. 13. Penalty for injury, trespass, etc. SEC. 14. Fraudulent use of gas. SEC. 15. "This act shall apply to all companies which manufacture gas for sale, and shall take effect July first, eighteen hundred and sixty-one. . . . Approved, April 10, 1861."

It was under this act that Hon. John A. Andrew, the famous "War" Governor of Massachusetts appointed as the first State Inspector of Gas Meters and Gas, the late Professor William Barton Rogers, founder and first president of the Massachusetts Institute of Technology. No further legislation of a sanitary sort appears to have been enacted until 1880.

* * * * *

Acts of 1880, chap. 230. *An Act in Addition to "An Act for the Inspection of Gas Meters, the Protection of Gas Consumers, and the Protection and Regulation of Gas Light Companies."*

SECTION 1. Assistant inspector of meters to be appointed by the Governor, etc. SEC. 2. Inspector and assistant to be paid traveling expenses. SEC. 3. Meters to be sealed. Penalty. SEC. 4. Company to provide a suitable room containing a disc photometer. SEC. 5. Inspection of Gas. (See Pub. Stat. 61 [14].) Read "provided" for "but" in sentence 1; "whenever" for "when" in sentence 4. Add to sentence 4: "but no fine for any impurities found before the first day of September, eighteen hundred and eighty shall be imposed"; read "whenever" for "when" in sentence 5. SEC. 6. Amendment of Act of 1861, chap. 168 (7). SEC. 7. Repeal of Act of 1861, chap. 168 (6). . . . Approved April 22, 1880.

This act of 1880, chap. 230, was introduced in the House on April 1, 1880, for the Committee on Manufactures and passed to second reading; third reading following on April 6; to be engrossed, April 11. It was introduced into the Senate and passed to second reading, April 13. Third reading was refused April 14; reconsideration was requested April 15; passed to third reading April 19; enacted April 22, 1880. These facts are interesting as showing that there was no serious opposition of any kind to the passage of the bill. A search of the files of the *Boston Transcript* for that period fails also to reveal any special interest in the subject and yet it was Section 5 of this Act of 1880 which, as we shall now see, prevented for the next ten years the legal manufacture and distribution of water gas for illuminating purposes.

* * * * *

Pub. Stat. Mass., Enacted November 19, 1881, to take effect February 1, 1882, Chap. 61. *Of the Inspection of Gas and Gas-Meters.*

SECTION 1. Appointment of inspector and assistant inspector and their terms of office. 1861, 168; 1880, 230. SEC. 2. Salaries, etc. SEC. 3. Bonds. SEC. 4. Inspector and assistant not to be interested in manufacture of gas, etc. SEC. 5.

General duties of inspector and assistant. SEC. 6. Appointment of deputy inspectors. Fees. SEC. 7. Salaries and expenses of inspector and his assistant to be paid into the State Treasury by gas companies. 1861, 168 (3); 1878, 223. SEC. 8. Standard measure for gas. SEC. 9. Apparatus and chemicals provided. SEC. 10. Gas-light companies and vendors of meters to provide test gas-holders and gas-meters, etc. SEC. 11. Meters not to be used unless stamped. SEC. 12. Testing of meters in use. SEC. 13. Gas-light companies to furnish room with photometer. SEC. 14. "The gas of every company supplying more than fifty consumers shall be inspected at least twice a year, and one additional inspection shall be made for every four million cubic feet of gas supplied by each company; but the gas of no company shall be inspected oftener than once a week. All such inspections shall be made by the inspector or his assistant and one-fourth at least of all such inspections shall be made by the inspector. The gas shall be tested for illuminating power by means of a disc photometer, and, during such test, shall be burned from the burner best adapted to it, which is at the same time adapted to domestic use, and at as near the rate of five feet per hour as is practicable. When the gas of any company is found on three consecutive inspections to give less light than fifteen standard English candles, or to contain more than twenty grains of sulphur or ten grains of ammonia per hundred cubic feet of gas, or more than 10 per cent of carbonic oxide, or any sulphuretted hydrogen, a fine of one hundred dollars shall be paid by such company to the city or town supplied by it. When during the test the consumption of gas varies from five feet per hour, or the candle from one hundred and twenty grains per hour, a proportional correction shall be made for the candle power." 1880, 230 (5). SEC. 15. Right of entrance. SEC. 16. Right to stop gas. SEC. 17. Penalty for injury to meter, etc. SEC. 18. For unlawfully using gas. SEC. 19. Companies to which chapter applies.

Under SEC. 14 above, the eight words "or more than 10 per cent of carbonic oxide" entirely prevented the legal distribution of water gas for illuminating purposes in Massachusetts. It was not until 1890 that this restriction was removed.

* * * * *

Acts of 1885, 240 (1). *Gas allowed for heating, cooking, chemical and mechanical purposes. Exemption granted from Pub. Stat., chap. 61, secs. 13 and 14.*

Be it enacted . . . as follows:

SECTION 1. The provisions of SECS. 11, 52 and 75 of chap. 106 of the Pub. Stat. are hereby extended so as to authorize the establishment and operation of corporations for the purpose of making, selling and distributing gas for heating, cooking, chemical and mechanical purposes. Said corporations shall have all the powers and privileges and be subject to all the duties, restrictions and liabilities set forth in all general laws which now or hereafter may be in force relating to gaslight companies; provided, however, that secs. 13 and 14 of chap. 61 of the Public Statutes shall not apply to gas made and used exclusively for heating, cooking, chemical and mechanical purposes. SEC. 2. Such gas shall not be used for domestic purposes unless connected with a chimney or flue having direct connection with the open air; provided, however, that nothing in this section shall be construed to apply to illuminating gas as defined by the provisions of sec. 14, chap. 61 of the Pub. Stat. Any violation of this section shall be punished by a fine not exceeding twenty dollars for each and every offense. SEC. 3 This act shall take effect upon its passage. . . . Approved May 15, 1885.

Acts of 1885, chap. 31. *An Act to Establish a Board of Gas Commissioners.*

SECTION 1. Board of Gas Commissioners to be appointed by Governor. Also clerk. SEC. 2. Term of office (3 yrs.). Vacancies. SEC. 3. Commissioners forbidden to be interested in sale of gas. SEC. 4. Salaries. SEC. 5. Incidental expenses. SEC. 6. Annual expenses to be assessed from gas companies. SEC. 7. Gas companies to make annual sworn returns. SEC. 8. Board to have supervision of corporations making and selling gas, etc. SEC. 9. Investigation of complaints, as to quality of gas. SEC. 10. Second gas company not to dig up streets without permission. SEC. 11. Purity of gas. May investigate and recommend regulations to the legislature. SEC. 12. Attorney-general must be notified if company neglects to comply with orders. SEC. 13. Provisions may be enforced in equity. SEC. 14. Annual report to legislature. SEC. 15. Gas inspectors to render assistance, etc. SEC. 16. Gas companies may appeal to Board in case of grievance. SEC. 18. Approved June 11, 1885.

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Acts of 1886, chap. 250.

Amends Pub. Stat., chap. 61, sec. 14, to read six million cubic feet instead of four million cubic feet.

* * * * *

Acts of 1888, chap. 350. *An Act in Addition to "An Act to Establish a Board of Gas Commissioners."*

SECTION 1. Fixing price. SEC. 2. All companies and individuals engaged in the business of manufacturing and selling gas and electricity for light or fuel shall make a written report within twenty-four hours to the Board of Gas Commissioners of every accident caused by the gas or electricity manufactured or supplied by them, whereby an employer or any other person shall suffer bodily injury or loss of life or be rendered insensible, stating the time, place and circumstances of the accident, and such other facts in relation thereto as the Board may require; and the Board shall present in its annual report an abstract of all such cases. The Board shall personally investigate all cases which it may deem to require investigation. SEC. 3. This act shall take effect on the 30th day of June, 1888. . . . Approved May 17, 1888.

* * * * *

Acts of 1888, chap. 428. *An Act Authorizing the Gas Commissioners to License Certain Gas Companies to Make and Sell Water Gas for Illuminating Purposes.*

SECTION 1. "The Board of Gas Commissioners is hereby authorized to license any company now authorized to make gas for illuminating purposes to make and sell water gas for illuminating purposes containing any percentage of carbonic oxide that said Board may determine: *provided* that such Board shall be of opinion and shall certify in any license granted by them that in their opinion the gas so authorized can be used with safety for such purposes, and after receiving such license said company shall be exempt from any penalty or prohibition provided in sec. 14, of chap. 61 of Pub. Stat. relating to carbonic oxide provided the percentage of carbonic oxide shall not exceed the limit allowed by said Board. SEC. 2. Any company which shall under the provisions of the first section of this act be licensed to make and sell water gas for illuminating purposes containing an excess of 10 per cent of carbonic oxide

shall furnish to every actual consumer a copy of the Gas Commissioners' license which shall contain a statement of the percentage of carbonic oxide such gas contains as near as can be ascertained. And no company so licensed shall charge more for water gas in any locality than is charged in that locality by any company furnishing gas therein when the manufacture and sale of such water gas is so licensed." SEC. 3. This act shall take effect upon its passage. . . . Approved May 29, 1888.

* * * * *

Acts of 1890, chap. 252. *An Act Removing Restrictions from the Manufacture and Sale of Water Gas for Illuminating Purposes.*

SECTION 1. Sec. 14, chap. 61, Pub. Stat. relating to inspection of gas is hereby amended by striking out in the fifteenth line the words "or more than 10 per cent of carbonic oxide," so that the last two clauses of said section as amended shall read as follows: "When the gas of any company is found on three consecutive inspections to give less light than fifteen standard English candles, or to contain more than twenty grains of sulphur or ten grains of ammonia per hundred cubic feet of gas, or any sulphuretted hydrogen, a fine of one hundred dollars shall be paid by such company to the city or town supplied by it. When during the test the consumption of gas varies from five feet per hour, or the candle from one hundred and twenty grains per hour, a proportionate correction shall be made for the candle power. SEC. 2. Chap. 428, Acts of 1888, authorizing Gas Commissioners to license gas companies to make and sell water gas for illuminating purposes is hereby repealed. SEC. 3. This act shall take effect upon its passage. . . . Approved April 30, 1890.

* * * * *

Acts of 1892, chap. 67. Raises candle power standard required from 15 to 16 standard candles.

Acts of 1902, chap. 228. (1) Transfers powers and duties of inspector of gas meters, etc., to Gas and Electric Light Commissioners.

Acts of 1903, chap. 464. Amends section providing for inspection and testing of illuminating gas. Modifies methods but not substances to be tested for.